

WE CLAIM:

1. A process for the production of biological products by microorganisms comprising the steps of:

5 selecting a microorganism that is capable of utilizing oxygen or an alternative oxidant source other than oxygen for cellular respiration;

providing a culture medium suitable for the growth of the microorganism, wherein the medium comprises at least one carbon source;

inoculating the culture medium with a desired cellular concentration of the microorganism;

10 aerating the culture medium with oxygen, wherein the process has a maximum oxygen supply rate to the culture medium;

supplying the culture medium with an alternative oxidant source, other than oxygen, such that when the oxygen requirements for cellular respiration of the microorganisms within the culture medium is less than the maximum rate of oxygen supply to the culture medium, then the microorganisms will substantially utilize oxygen for cellular respiration, and when the oxygen requirements for cellular respiration of the microorganisms within the culture medium is greater than the maximum rate of oxygen supply to the culture medium, then a portion of the microorganisms within the culture medium will utilize the alternative oxidant source for cellular respiration;

20 maintaining the culture medium at a desired pH and temperature; and

allowing the culture medium to incubate for a time sufficient to produce a desired quantity of a biological product.

2. The process of claim 1, further comprising the steps of isolating and recovering said biological product from said culture media.

3. The process of claim 1, wherein the microorganism is selected from the group consisting of bacteria, yeasts, molds and archaea.

4. The process of claim 3, wherein the microorganism is a bacteria.

5. The process of claim 4, wherein bacteria is a facultative aerobe.

5 6. The process of claim 5, wherein the facultative aerobe is from a genus selected from the group consisting of *Pseudomonas*, *Paracoccus*, *Micrococcus*, *Klebsiella*, *Escherichia*, *Acidianus*, *Campylobacter*, *Wolinella*, *Desulfovibrio*, *Clostridium*, and *Proteus*.

10 7. The process of claim 6, wherein the genus is *Pseudomonas*.

8. The process of claim 7, wherein the species of the genus *Pseudomonas* is selected from the group consisting of *Pseudomonas aeruginosa*, *Pseudomonas fluorescens*, *Pseudomonas putida*, *Pseudomonas cruciviae*, *Pseudomonas boreopolis*
15 and *Pseudomonas oleovorans*.

9. The process of claim 8, wherein the species of *Pseudomonas* is *Pseudomonas aeruginosa*.

20 10. The process of claim 1, wherein the carbon substrate is selected from the group consisting of fatty acids, glycerol, low molecular weight acids, carbohydrates, yeast extract, peptone and vegetable oil.

11. The process of claim 10, wherein the fatty acids are selected from the group
25 consisting of palmitic acid, stearic acid, oleic acid, linoleic acid, arachidic acid, butyric acid, caproic acid, lauric acid, and linolenic acid.

12. The process of claim 11, wherein the fatty acid is palmitic acid.

13. The process of claim 10, wherein the vegetable oil is selected from the group consisting of corn oil, peanut oil, coconut oil, linseed oil, olive oil, soy bean oil and sunflower oil.

5 14. The process of claim 13, wherein the vegetable oil is corn oil.

15. The process of claim 10, wherein the carbohydrate is glucose.

16. The process of claim 10, wherein the low molecular weight acid is selected
10 from the group consisting of malate, acetate and pyruvate.

17. The process of claim 1, wherein the alternative oxidant source is selected from
the group consisting of nitrates, nitrites, sulfates, sulfites, carbonates, fumarates,
sulfur, manganic ion, ferric ion, selenate, dimethyl sulfoxide, arsenate, trimethylamine-
15 N-oxide and glycine.

18. The process of claim 17, wherein the alternative oxidant source is a nitrate.

19. The process of claim 18, wherein the nitrate is selected from the group
20 consisting of sodium nitrate, potassium nitrate, calcium nitrate, magnesium nitrate,
ammonium nitrate, and nitric acid.

20. The process of claim 19, wherein the nitrate is sodium nitrate.

21. The process of claim 17, wherein the nitrites are selected from the group
25 consisting of sodium nitrite, potassium nitrite, calcium nitrite, ammonium nitrite, and
nitrous acid.

22. The process of claim 17, wherein the sulfates are selected from the group consisting of sodium sulfate, potassium sulfate, calcium sulfate, iron sulfate, magnesium sulfate, ammonium sulfate, zinc sulfate, copper sulfate, cobalt sulfate, manganese sulfate, and dilute sulfuric acid.

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23. The process of claim 17, wherein the sulfites are selected from the group consisting of calcium sulfite, sodium sulfite, potassium sulfite, iron sulfite, magnesium sulfite, ammonium sulfite, zinc sulfite, copper sulfite, cobalt sulfite and manganese sulfite.

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24. The process of claim 17, wherein the carbonates are selected from the group consisting of calcium carbonate, sodium carbonate, and potassium carbonate.

25. The process of claim 17, wherein the bicarbonates are selected from the group consisting of calcium bicarbonate, sodium bicarbonate, and potassium bicarbonate.

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26. The process of claim 17, wherein the fumarates are selected from the group consisting of disodium fumarate, sodium fumarate, dipotassium fumarate, potassium fumarate, and fumaric acid.

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27. The process of claim 1, further comprising the step of adding a sufficient amount of a surfactant to said culture medium to facilitate the mass transfer of said carbon substrate into said culture medium.

28. The process of claim 1, further comprising the step of limiting an essential growth nutrient from the culture medium.

29. The process of claim 28, wherein the essential growth nutrient is selected from the group consisting of phosphorous, nitrogen, sulfur, calcium, magnesium and iron.

30. The process of claim 29, wherein the essential growth nutrient is phosphorous.

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31. The process of claim 1, wherein said cellular concentration of said microorganism is from about 0.1 g/L to about 50 g/L.

10 32. The process of claim 1, wherein the concentration of the alternative oxidant source in the culture medium is in the range of from about 0.01 to about 10 g/L.

33. The process of claim 1, wherein the culture is maintained in a temperature range of about 20°C to about 40 °C.

15 34. The process of claim 1, wherein the culture is maintained in a pH range of about 4 to about 9.

35. A process for the preparation of biological products under anaerobic respiring conditions comprising:

20 selecting a microorganism that is capable of utilizing an alternative oxidant source other than oxygen for cellular respiration under anaerobic conditions;

providing a culture medium suitable for the growth of the microorganism, wherein the medium comprises at least one carbon source;

25 inoculating the culture medium with a desired cellular concentration of the microorganism;

supplying an alternative oxidant source other than oxygen to the culture medium;

maintaining the culture medium at a desired pH and temperature; and
allowing the culture medium to incubate for a time sufficient to produce a
desired quantity of a biological product.

5 36. The process of claim 35, further comprising the steps of isolating and
recovering said biological product from said culture media.

37. The process of claim 35, wherein the microorganism is selected from the group
consisting of bacteria, yeasts, mold and archaea.

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38. The process of claim 37, wherein the microorganism is a bacteria.

39. The process of claim 38, wherein the bacteria is selected from the group
consisting of obligate anaerobes and facultative aerobes.

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40. The process of claim 39, wherein the obligate anaerobe is from a genus selected
from the group consisting of *Desulfovibrio*, *Desulfomonas*, *Desulfotomaculum*,
Desulfobulbus, *Desulfococcus*, *Desulfobacter*, *Desulfosarcine*, *Desulfonema*,
Desulfurmonas, *Thermoproteus*, *Pyrococcus*, *Thermococcus*, and *Shewanella*.

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41. The process of claim 40, wherein the facultative aerobe is from a genus selected
from the group consisting of *Pseudomonas*, *Paracoccus*, *Micrococcus*, *Klebsiella*,
Escherichia, *Acidianus*, *Campylobacter*, *Wolinella*, *Desulfovibrio*, *Clostridium*, and
Proteus.

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42. The process of claim 41, wherein the genus is *Pseudomonas*.

43. The process of claim 42, wherein the species of the genus *Pseudomonas* is selected from the group consisting of *Pseudomonas aeruginosa*, *Pseudomonas fluorescens*, *Pseudomonas putida*, *Pseudomonas cruciviae*, *Pseudomonas boreopolis* and *Pseudomonas oleovorans*.

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44. The process of claim 43, wherein the species of *Pseudomonas* is *Pseudomonas aeruginosa*.

45. The process of claim 35, wherein the carbon substrate is selected from the group consisting of fatty acids, glycerol, low molecular weight acids, carbohydrates, yeast extract, peptone and vegetable oil.

46. The process of claim 45, wherein the fatty acids are selected from the group consisting of palmitic acid, stearic acid, oleic acid, linoleic acid, arachidic acid, butyric acid, caproic acid, lauric acid, and linolenic acid.

47. The process of claim 46, wherein the fatty acid is palmitic acid.

48. The process of claim 45, wherein the vegetable oil is selected from the group consisting of corn oil, peanut oil, coconut oil, linseed oil, olive oil, soy bean oil and sunflower oil.

49. The process of claim 48, wherein the vegetable oil is corn oil.

50. The process of claim 45, wherein the carbohydrate is glucose.

51. The process of claim 45, wherein the low molecular weight acid is selected from the group consisting of malate, acetate and pyruvate.

52. The process of claim 35, wherein the alternative oxidant is selected from the
5 group consisting of nitrates, nitrites, sulfates, sulfites, carbonates, fumarates, sulfur, manganic ion, ferric ion, selenate, dimethyl sulfoxide, arsenate, trimethylamine-N-oxide and glycine.

53. The process of claim 52, wherein the alternative oxidant source is a nitrate.
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54. The process of claim 53, wherein the nitrate is selected from the group consisting of sodium nitrate, potassium nitrate, calcium nitrate, magnesium nitrate, ammonium nitrate, and nitric acid.

15 55. The process of claim 54, wherein the nitrate is sodium nitrate.

56. The process of claim 35, wherein the nitrites are selected from the group consisting of sodium nitrite, potassium nitrite, calcium nitrite, ammonium nitrite, and nitrous acid.

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57. The process of claim 35, wherein the sulfates are selected from the group consisting of sodium sulfate, potassium sulfate, calcium sulfate, iron sulfate, magnesium sulfate, ammonium sulfate, zinc sulfate, copper sulfate, cobalt sulfate, manganese sulfate, and dilute sulfuric acid.

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58. The process of claim 35, wherein the sulfites are selected from the group consisting of calcium sulfite, sodium sulfite, potassium sulfite, iron sulfite, magnesium

sulfite, ammonium sulfite, zinc sulfite, copper sulfite, cobalt sulfite and manganese sulfite.

59. The process of claim 35, wherein the carbonates are selected from the group
5 consisting of calcium carbonate, sodium carbonate, and potassium carbonate.

60. The process of claim 35, wherein the bicarbonates are selected from the group consisting of calcium bicarbonate, sodium bicarbonate, and potassium bicarbonate.

10 61. The process of claim 35, wherein the fumarates are selected from the group consisting of disodium fumarate, sodium fumarate, dipotassium fumarate, potassium fumarate, and fumaric acid.

62. The process of claim 35, further comprising the step of adding a sufficient
15 amount of a surfactant to said culture medium to facilitate the mass transfer of said carbon substrate into said culture medium.

63. The process of claim 35, further comprising the step of limiting an essential growth nutrient from the culture medium.

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64. The process of claim 63, wherein the essential growth nutrient is selected from the group consisting of phosphorous, nitrogen, sulfur, calcium, magnesium and iron.

65. The process of claim 64, wherein the essential growth nutrient is phosphorous.

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67. The process of claim 35, wherein said cellular concentration of the microorganism in the culture medium is in the range of from about 0.1 g/L to about 50 g/L.

5 68. The process of claim 35, wherein the concentration of the alternative oxidant source in the culture medium is in the range of from about 0.01 to about 10 g/L.

69. The process of claim 35, wherein the culture is maintained in a temperature range of about 20°C to about 40 °C.

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70. The process of claim 35, wherein the culture is maintained in a pH range of about 4 to about 9.

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71. A process for increasing concentration of microorganisms in a defined medium comprising the steps of:

selecting a microorganism that is capable of utilizing oxygen or an alternative oxidant source other than oxygen for cellular respiration;

providing a culture medium suitable for the growth of the microorganism, wherein the medium comprises at least one carbon source;

20 inoculating the culture medium with a desired cellular concentration of the microorganism;

aerating the culture medium with oxygen, wherein the process has a maximum oxygen supply rate to the culture medium;

25 supplying the culture medium with an alternative oxidant source, other than oxygen, such that when the oxygen requirements for cellular respiration of the microorganisms within the culture medium is less than the maximum rate of oxygen supply to the culture medium, then the microorganisms will substantially utilize oxygen

5 maintaining the culture medium at a desired pH and temperature; and.

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